Collaboration PoliMi – Nokia Vimercate – 2022/2023

General considerations

In the following document there is the detailed description of the proposed projects. The number of people associated to each project depends on the different scenarios the students want to investigate (e.g., if ILP or GA have to be implemented or not, implementation of the Auxiliary Graph, …).

Any project could be modified and simplified depending on the number of students that want to work on the project.

About the simulation assumptions, students are invited to use the data provided in Section 2.

In case there is any doubts on the project aim or inputs, students are invited to contact Annalisa Morea or Michael Recalcati at the following email addresses: annalisa.morea@nokia.com, michael.recalcati@nokia.com

Project 8: Hard-spectrum partitioning

Goal: assess overall spectral efficiency in a network with multiple channel widths, where fiber spectrum is hardly divided into 2 sections.

The spectrum in the fiber is divided into 2 sections: 50GHz and 75GHz. For each service, the tool must decide if it is better to route it using modulation formats at 50GHz or 75GHz bandwidth; and the optical channel is routed only in the spectrum part associated to its width.

Implement the behavior described above, computing spectrum occupation as a function of increasing traffic.

Compare these results with another scenario where the channel width is an input, and it is possible to allocate a 75GHz channel in 50GHz spectrum region (or vice versa) without restriction.

Simulation Goals

- Minimize blocking probability;
- Minimize overall cost of the network (OEO devices used for add/drop and regeneration).

Network and traffic assumptions

Students can run their simulations using both national and continental networks: their characteristics are described in Section 2.a) of this document.

About traffic assumptions, the traffic shall be generated as described in Section 2.b) of this document.

About the modulation level, students must consider values for long reach OEO devices with 50 and 75GHz channel spacing presented in Section 2.c).i.

2. Network and Traffic assumptions

The network comparison shall be estimated for backbone and national wide networks. The students can select any network available in Net2Plan inputs, but the network characteristics have to satisfy the features described in Section 3.a) of this document.

About traffic assumptions, the traffic shall be generated as described in Section 3.b) of this document.

About the modulation format, symbol rate and optical reach, students must take into account values presented in Section 3.c).

About the cost for comparing long reach and ZR+ OEO devices, please refer to values presented in Section 3.d).

3. Simulation assumptions

a) Network types

Students can use any network that is available in Net2Plan. The networks could be divided in Continental and National wide, and must satisfy the following features:

	Continental	**National**
Number of links	≥ 20 links	≤ 20 links
Average link length	~ 300 km	~ 150 km
Max link length	~ 1000 km	~ 400 km

I. North American network

US_Network_with_TI.docx

North American network to be taken as reference for Project 7 can be found here:

b) Traffic generation

Traffic will be generated by drawing random matrices with all services that will fill Optical Channels with at least 100Gb/s of capacity.

The simulations shall be done for different traffic load. The minimum load will contain 350 services, then increase the traffic load with a step of 50 services. The maximum load will be the one for which 1% of nominal services is blocked.

c) OEO modulation levels

The OEO devices (transponders and regenerators) can adopt one of the following modulation formats with associated the distance reach indicated in the table.

The reaches provided in the following tables are associated to a system based on SSMF fibers amplified with EDFAs.

Modulation levels for long reach OEO devices

Data Rate (Gb/s)	**Modulation format**	**Bits/symbol (Gb/s) - Entropy**	**Channel spacing Δf (GHz)**	**Reach (km)**
800	PCS 64 QAM	5.67	100	150
700	PCS 64 QAM	5.00	100	400
600	16 QAM	4.00	100	700
500	PCS 16 QAM	3.60	100	1300
400	PCS 16 QAM	3.00	100	2500
300	PCS 16 QAM	2.39	100	4700
300	64 QAM	6.00	50	100
200	16 QAM	4.00	50	900
100	QPSK	2.00	50	3000

Modulation levels for ZR+ OEO devices

Data Rate (Gb/s)	Modulation format	Bits/symbol (Gb/s)	Channel spacing Δf (GHz)	Reach (km)
400	16 QAM	4	75	600
300	8 QAM	3	75	1800
200	QPSK	2	75	3000
100	QPSK	2	50	3000

i. Channel characteristics for spectrum segregation study

Data Rate (Gb/s)	Modulation format	Bits/symbol (Gb/s)	Channel spacing Δf (GHz)	Reach (km)
400	16 QAM	4	75	700
200	16 QAM	4	50	700

d) Cost of devices

The following table considers the cost of OEO transponders. Please consider that 3R regenerators are realized with transponders in a back-to-back configuration, so their cost twice a transponder.

	Arbitrary Unit (a.u.)
Cost of long reach OEO	1
Cost of ZR+	0.5
Cost of client cards plugged on long reach OEO (@100G)	0.07

Cost for OCh traffic interruption: 1 transponder cost at T0, whatever the considered

e) Energy consumption of OEO devices

Students will ask to PoliMi team about values